



Finnish Meteorological Institute



Earth Observation Unit



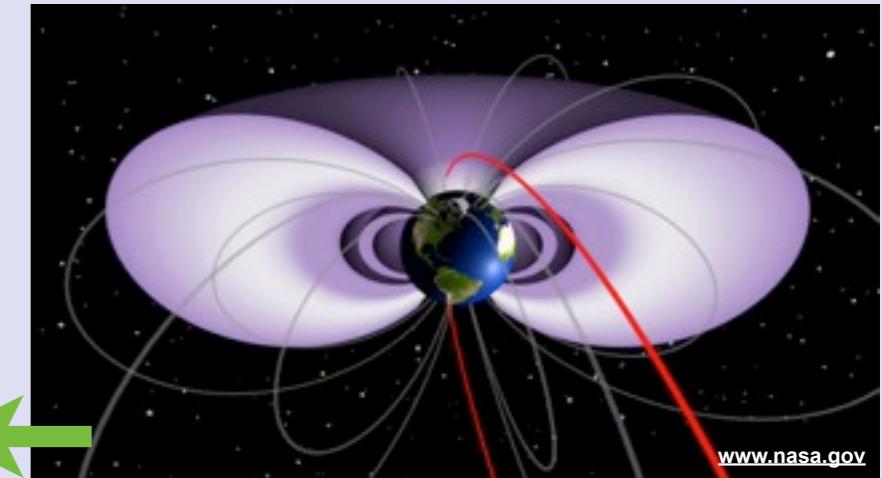
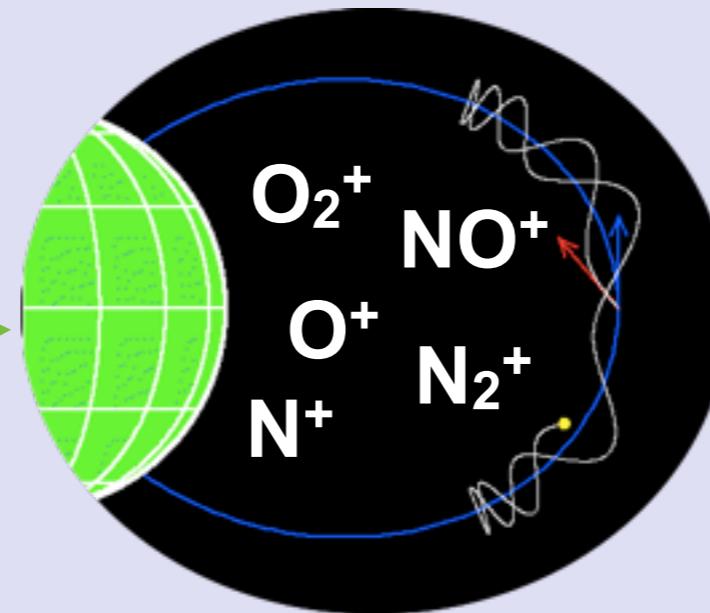
Precipitating radiation belt electrons and enhancements of mesospheric hydroxyl: observations and modeling

Monika E. Andersson, Pekka T. Verronen, Shuhui Wang, Craig J. Rodger, Mark A. Clilverd and Bonar R. Carson

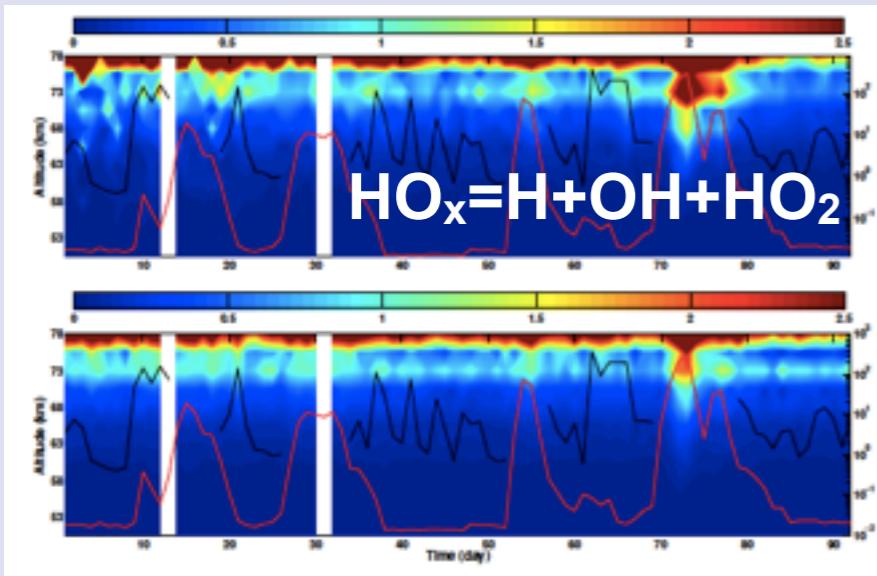
Introduction



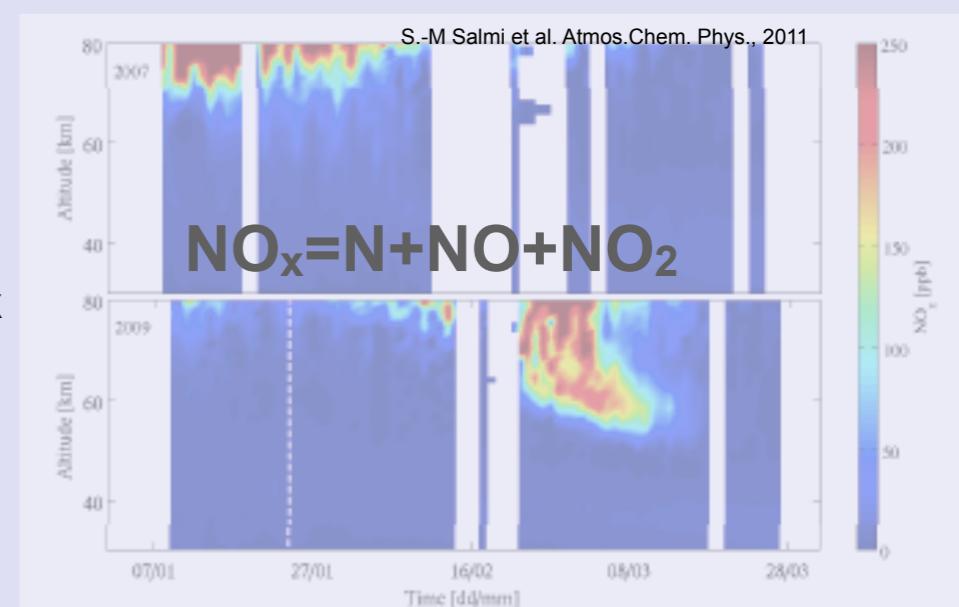
N₂ and O₂ ionization



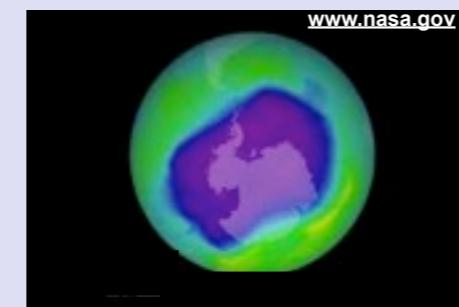
water cluster ion chemistry



enhanced HO_x and NO_x



mesospheric ozone loss



Data

MLS AURA

Data: Version 3.3 Level 2 nighttime OH, H₂O and T

Time period: August 2004-December 2009

Geomagnetic latitudes: 55-65° N/S

Altitude range: 70-78 km



MEPED POES

Data:

ECR from 0° detector pointing radially outwards along the Earth-satellite direction from Polar Orbiting Environmental Satellite

L shells: 3.5-5.5 - inner and mid parts of the outer radiation belt



Energy channels: >100 keV - >300 keV
ECR during solar proton events excluded from analysis

SPEs Lyman α

SPEs: >5 and >10 MeV proton fluxes from Geostationary Operational Environmental Satellite (GOES-11)

Lyman α: fluxes from LASP Interactive Solar Irradiance Data center

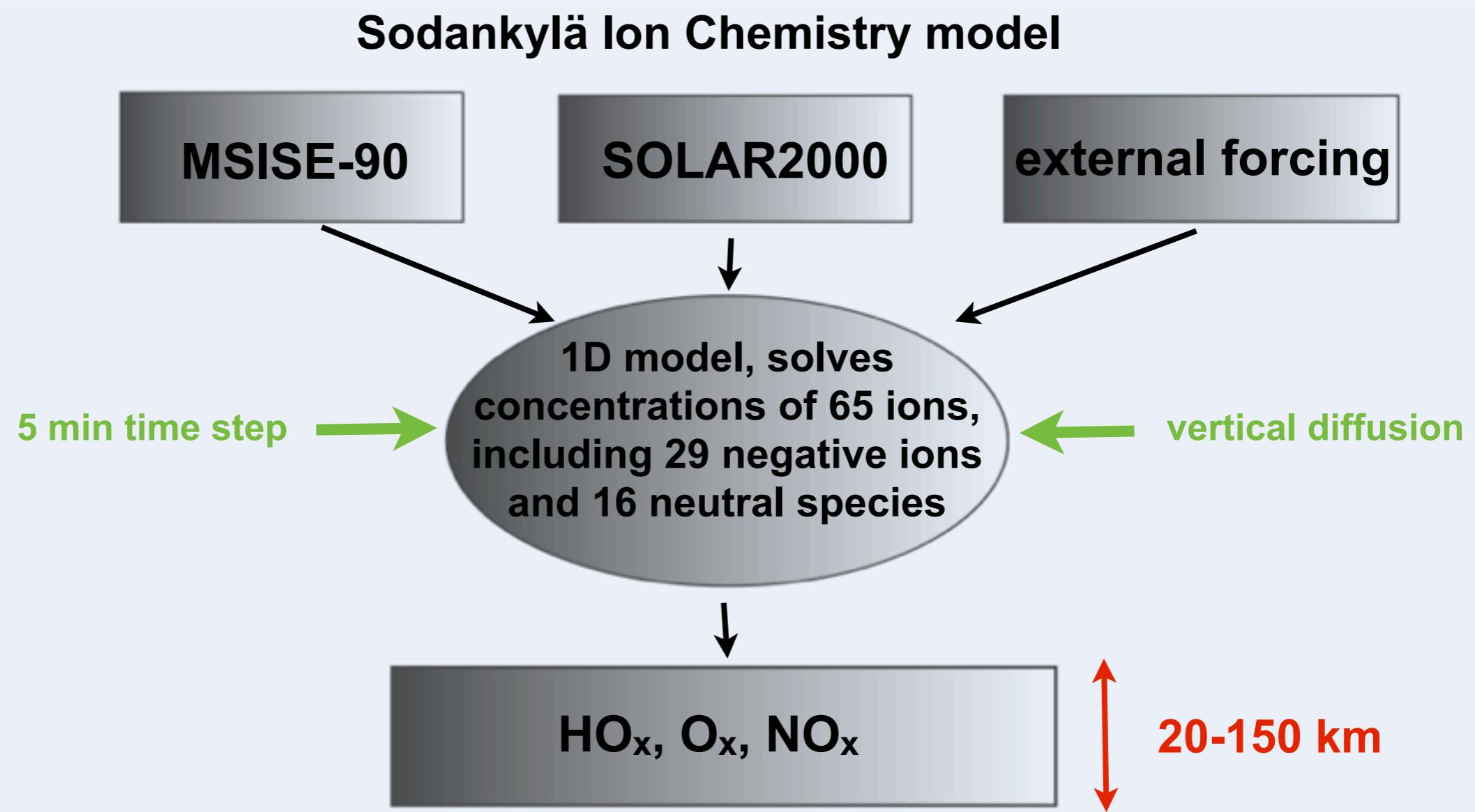


Method and model

Method

- Pearson's product-moment correlation
- 1st- and 2nd - order partial correlation
- Statistical robustness: p value (t-test) and bootstrap method

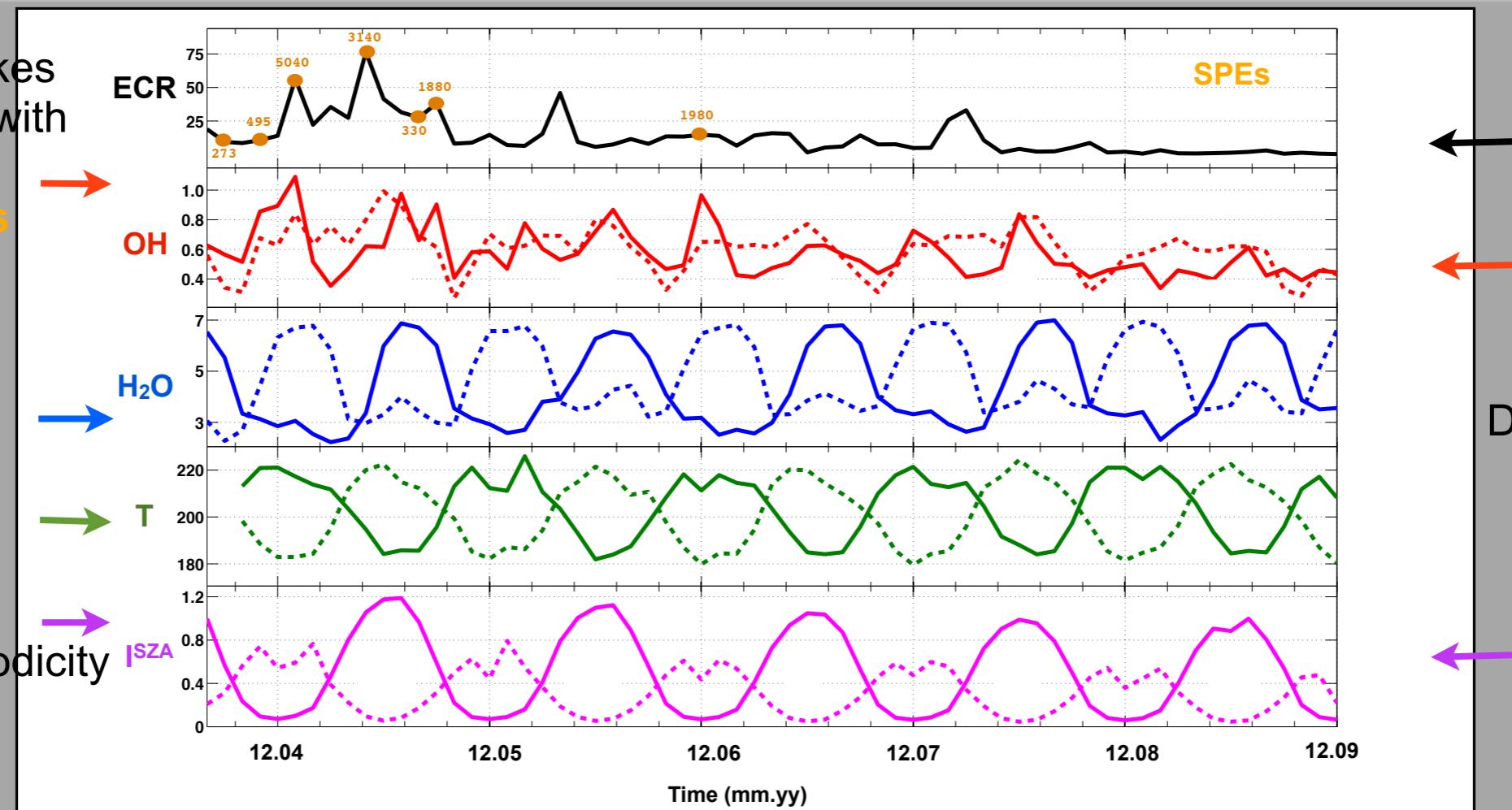
SIC Model



Results

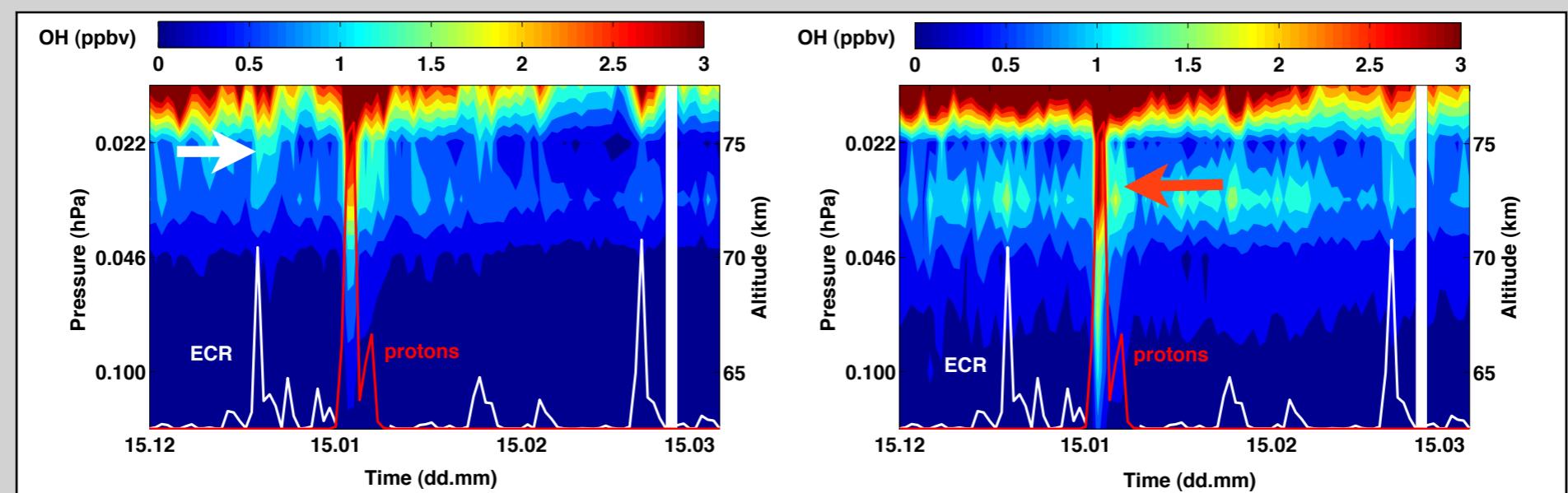
MLS OH variations

OH exhibits spikes which coincide with particle forcing, especially SPEs



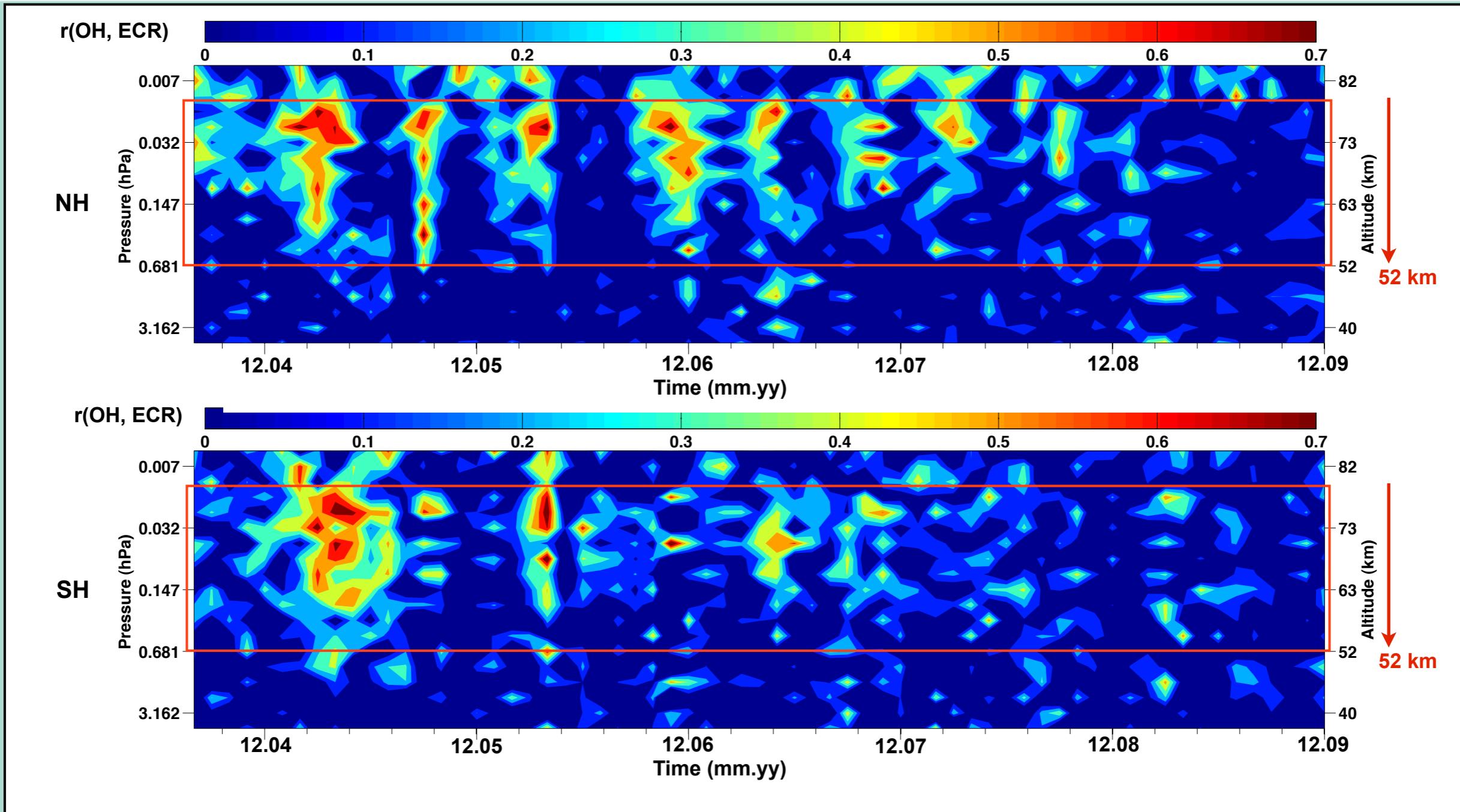
H₂O, T, Lyman α
clear annual periodicity

Decreasing trend



Results

Correlation analysis



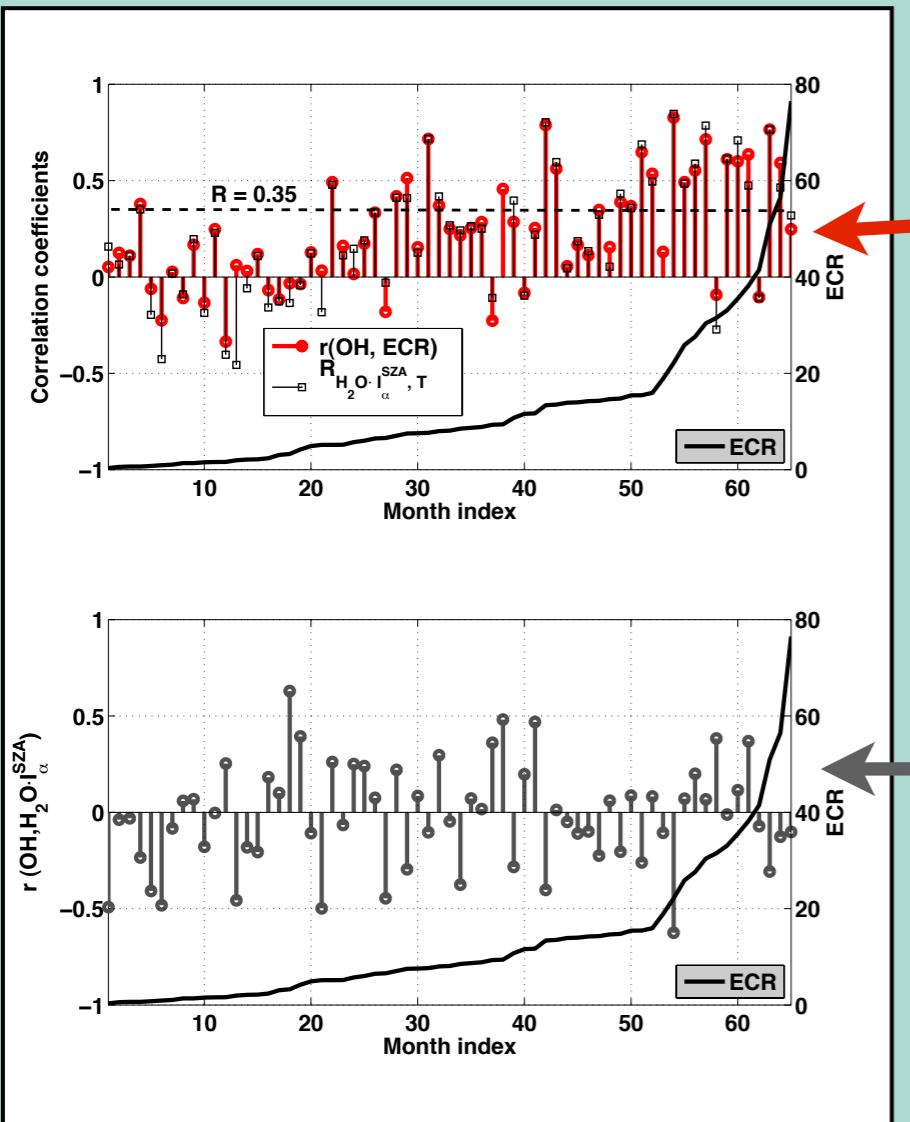
- Correlation between OH and precipitating electrons is high for almost all the months with days of very high ECR
- At 75 km, for 22 months (34%) of the total of 65 analyzed in the NH and for 20 months (31%) in the SH, correlation is significant ($r>0.35$, $p<0.05$)
- In 10 cases in the NH and 5 in the SH $r>0.6$



Results

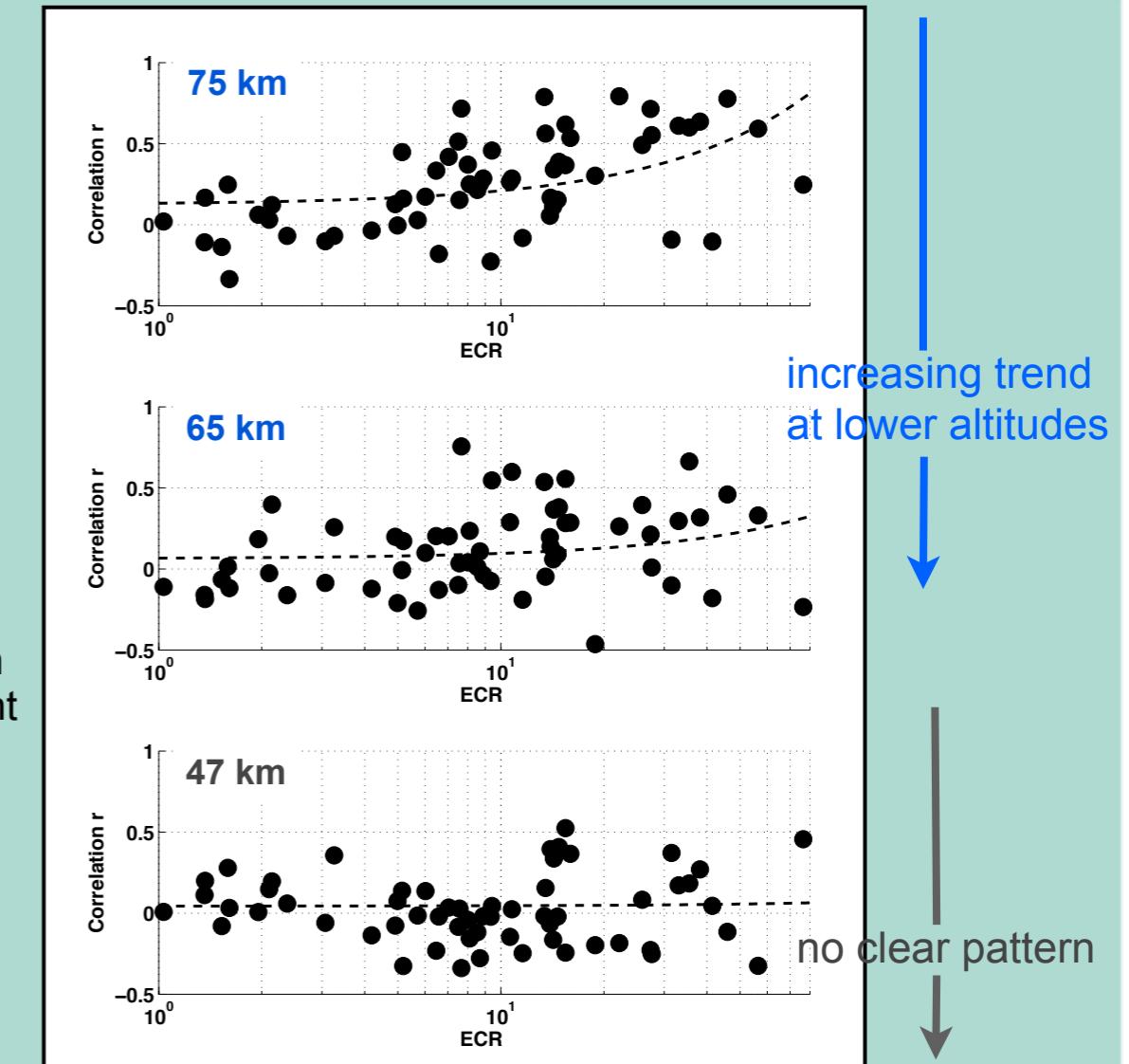
Correlation analysis

Northern Hemisphere



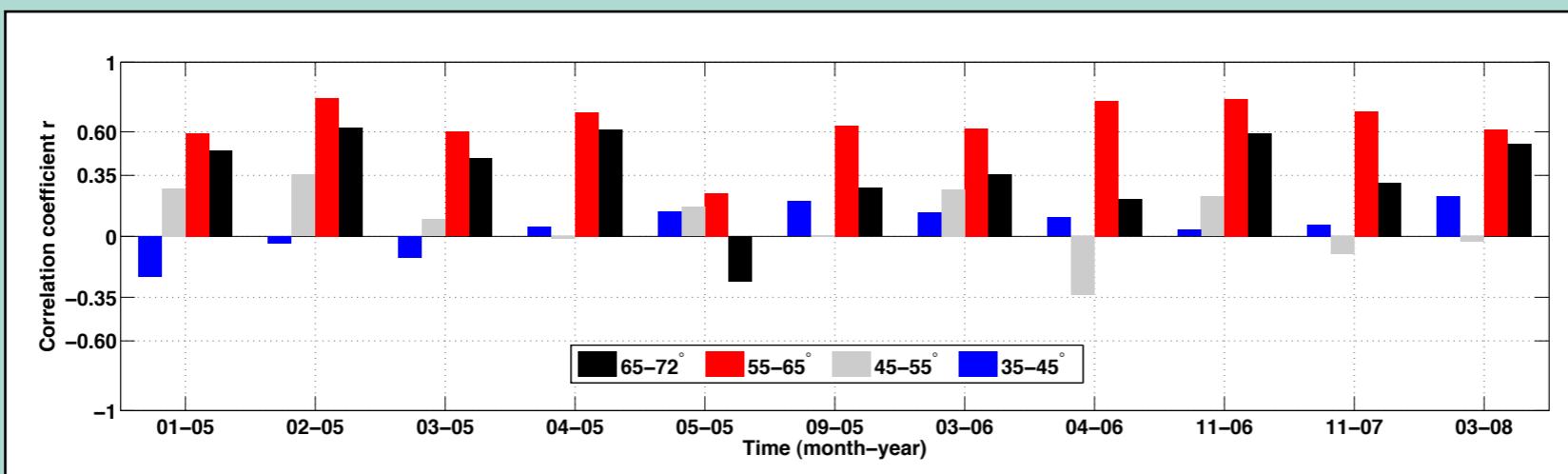
$r(\text{OH}, \text{ECR})$ increases with increasing ECR

$r(\text{OH}, \text{H}_2\text{O} \cdot \text{I}^{\text{SZA}})$: correlation dependency on the amount of electron precipitation is random



increasing trend at lower altitudes

no clear pattern



- The strongest correlation at 55-65 for all cases

- High correlation also for the latitudinal band 65-72



Results

SIC model

- SIC model was run for 4 cases with high EEP i.e., **January, March, May 2005 April 2006** at 2 locations: 60° N/ 0° E, 65° S/ 0° E

- 2 model runs for each location:
 - 1) **electron run** with the electron forcing
 - 2) **control run** - constant electron forcing: quiet time condition

- MLS total number density, H₂O and T averaged over each selected month were used in the model runs

The electron fluxes, required for ionization rates calculations estimated from MEPED/POES

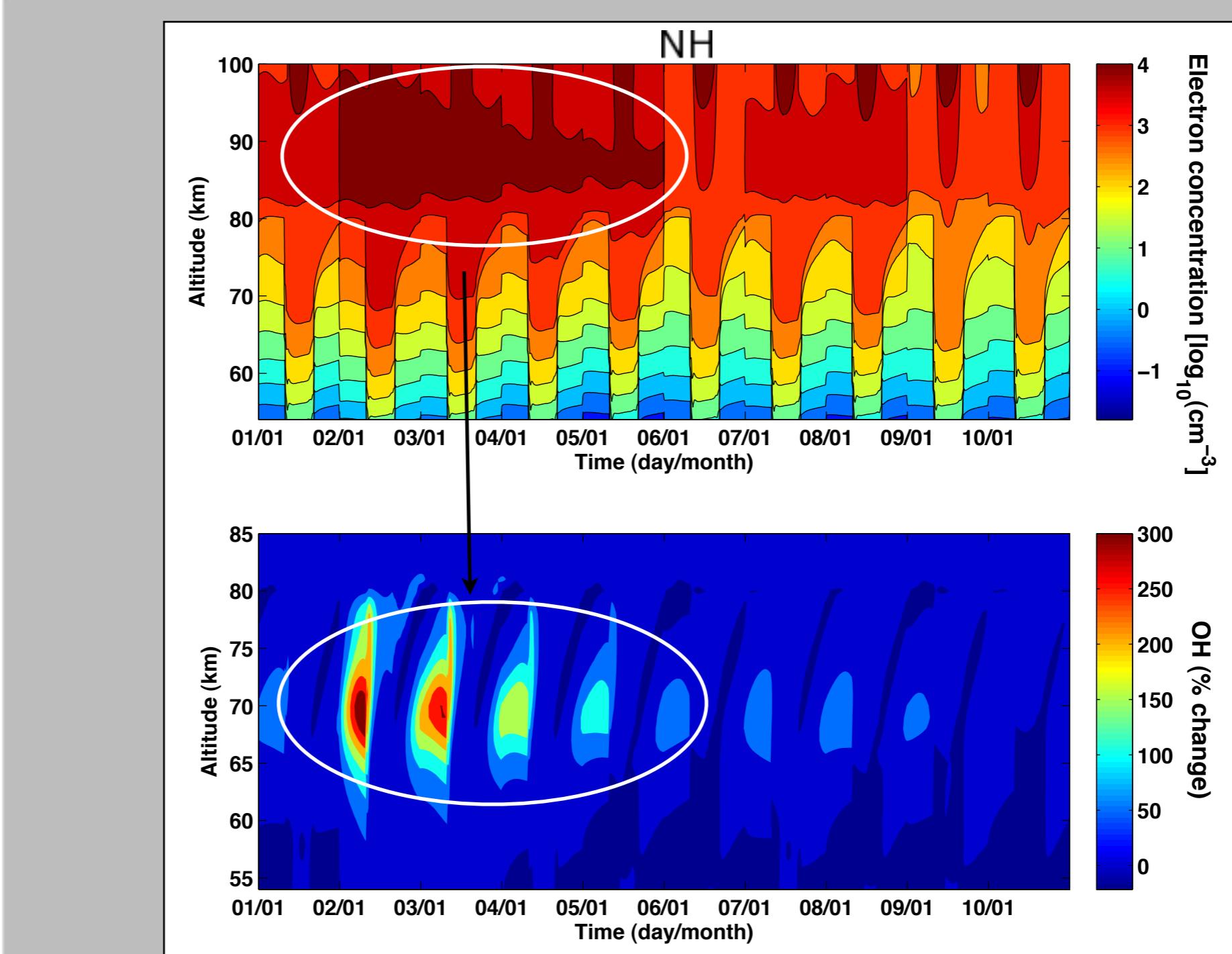


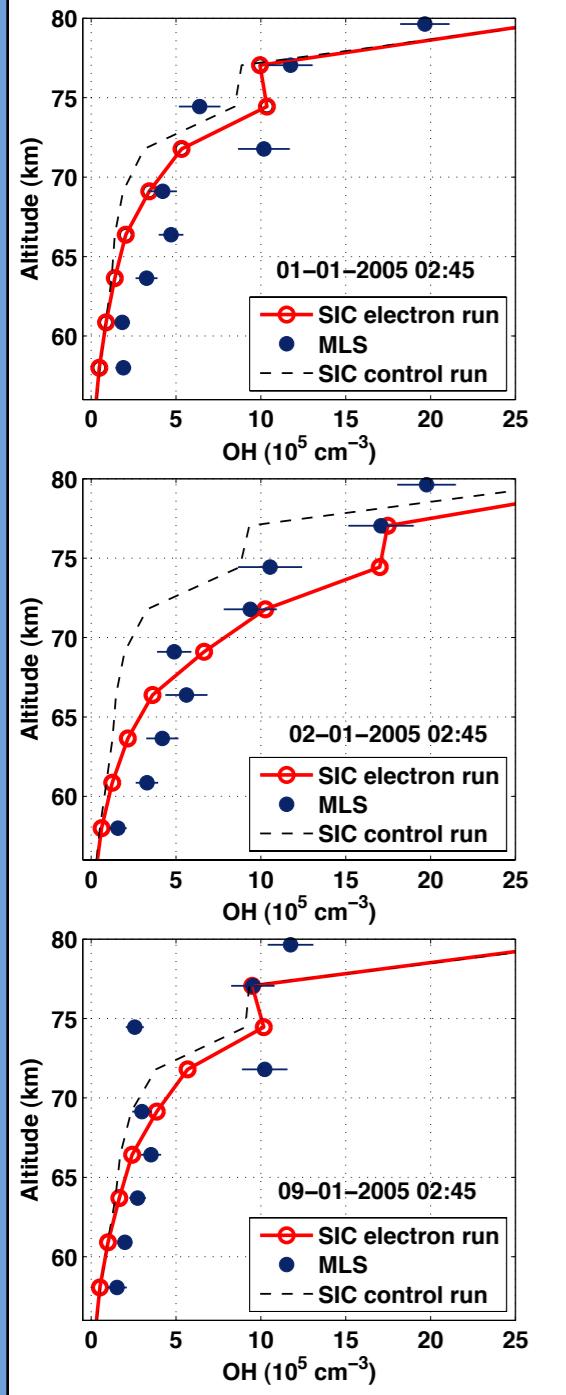
Fig. Mesospheric response to the energetic electron precipitation in January 2005 - model results



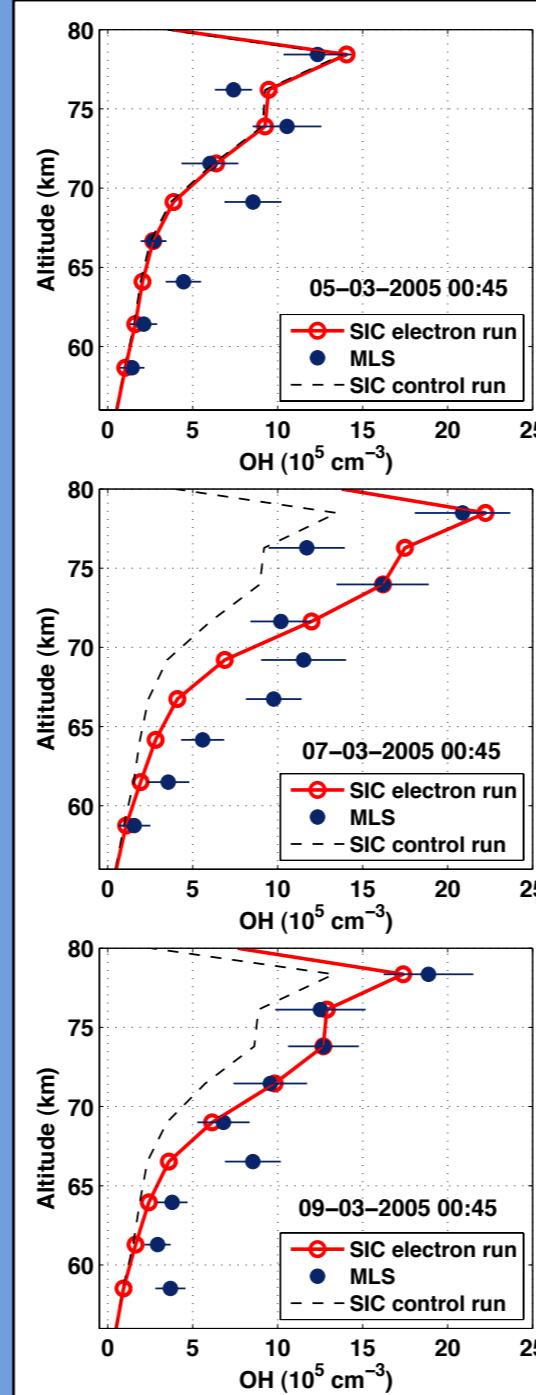
Results

Comparison between satellite observations and model

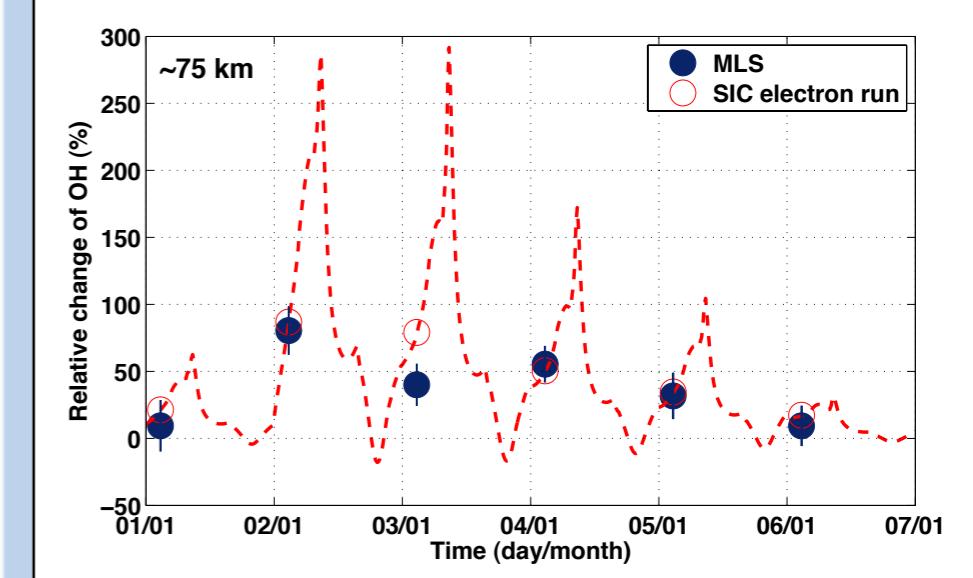
January 2005, NH



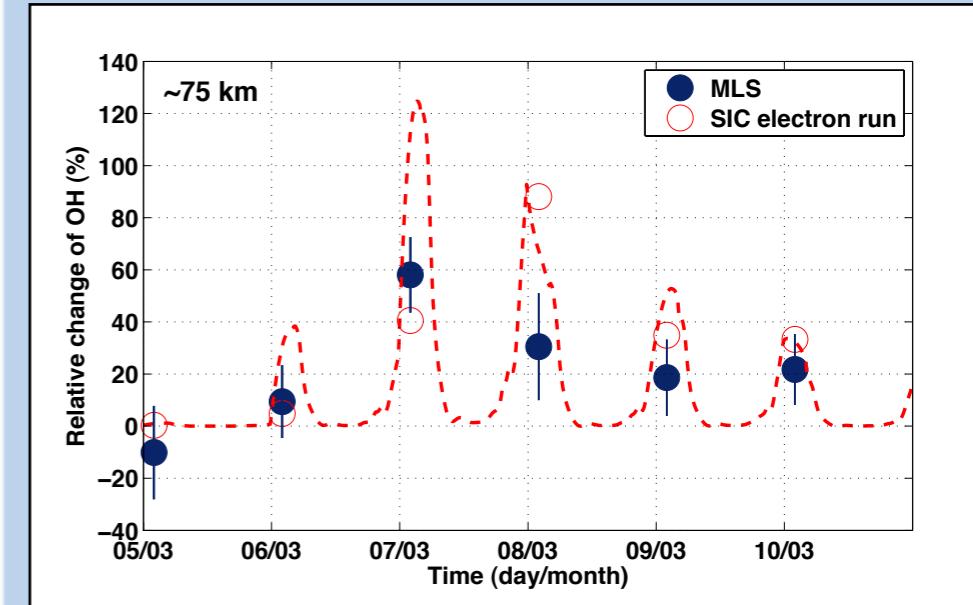
March 2005, SH



January 2005, NH



March 2005, SH



Conclusions

EEP & OH

- EEP is a significant source of mesospheric OH at latitudes connected to the outer radiation belt
- Between 70-78 km altitudes in 22 out of 65 months (34%) in the NH and in 20 out of 65 months (31%) in the SH, the correlation is statistically significant and indicates a measurable EEP effect on OH
- No evident correlation between ECR and OH below 52 km, >3 MeV electrons do not have a detectable impact on OH in the stratosphere
- EEP primarily affects magnetic latitudes 55 - 72°

Model

- SIC model results are in a reasonably good agreement with MLS hydroxyl observations
- Both, SIC model and satellite observations show about 90-150/ 50-300% increase N/S between 70-78 km during EEP

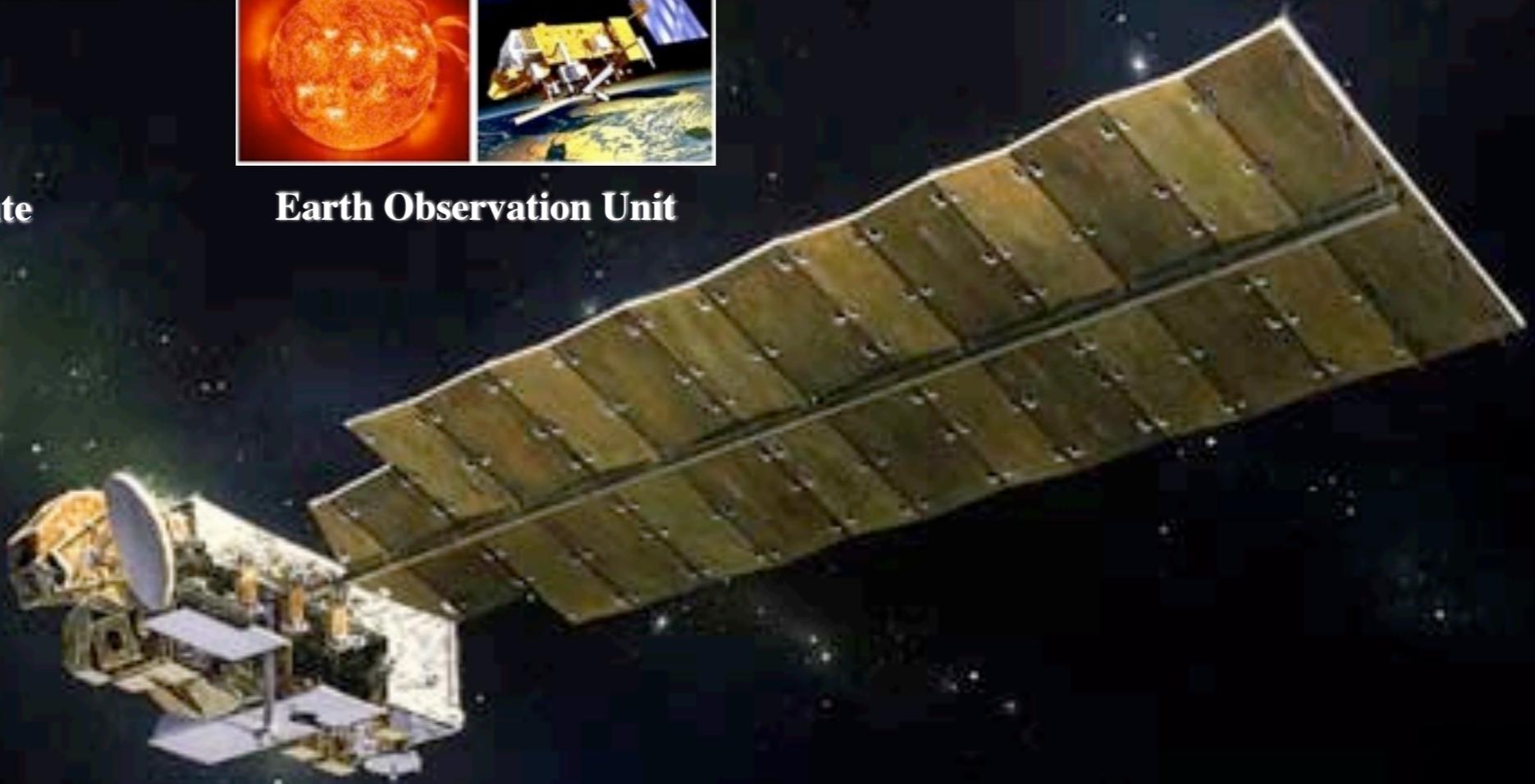




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Thank you for your attention!